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8	BRS	527	438/638.ccls.	USPAT; US-PGPUB; EPO; JPO	2003/07/17 14:49

Silicon monoxide

- **Formula:** OSi
- **Molecular Weight:** 44.08
- **CAS Registry Number:** 10097-28-6
- **Other Names:** Silicon(II) oxide; SiO; Silylene, oxo-; Silicon oxide; Monox
- Notes / Error Report
- **Other Data Available:**
  - Gas phase thermochemistry data
  - Gas phase ion energetics data
  - Constants of Diatomic Molecules
  - Gas phase kinetics (on kinetics web site)
- Switch to calorie-based units

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Glass

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3. Composition

Conditions favorable for glass formation may be deduced from either geometric or bond strength considerations. On the basis of the rules (21) discussed above, the following oxides should be glass formers: B_2O_3, SiO_2, GeO_2, P_2O_5, As_2O_5, P_2O_3, As_2O_3, Sb_2O_3, V_2O_5, Sb_2O_5, Nb_2O_5, and Ta_2O_5. In fact, they are all so used. The only fluoride that fulfills the rules of glass formation is BeF_2, which readily forms a glass (31).

Glass formers generally have cation–oxygen bond strengths greater than 335 kJ/mol (80 kcal/mol). In multiple-component systems, oxides with lower bond strengths do not become part of the network and are called modifiers. Oxides with energies of ca 335 kJ/mol may or may not become part of the network and are referred to as intermediates. The dissociation energies used to predict glass formation are calculated, taking into account the coordination number of the cation (Table 1). In multiple-component glasses, the terms formers, modifiers, and intermediates are frequently used to define the role of the individual oxides. However, an element such as lead may be either a modifier or intermediate, depending on its coordination and the glass system considered.

Table 1. Coordination Number and Bond Strengths of Oxides[a]

Name	Formula	CAS Registry Number	Dissociation energy, kJ/mol[b]	Coordination number	Single-bond strength, kJ/mol[b]
			Formers		
boron oxide	B_2O_3	[1303-86-2]	1489	3	496
silicon oxide	SiO_2	[10097-28-6]	1774	4	443
germanium oxide	GeO_2	[1310-53-8]	1803	4	450

aluminum oxide	Al_2O_3	[1344-28-1]	1682–1326	4	420–332
boron oxide	B_2O_3	[1303-86-2]	1489	4	372
phosphorus oxide	P_2O_5	[1314-56-3]	1849	4	462–370
vanadium oxide	V_2O_5	[1314-62-1]	1879	4	469–376
arsenic oxide	As_2O_5	[1303-28-2]	1460	4	365–292
antimony oxide	Sb_2O_5	[1314-60-9]	1418	4	354–284
zirconium oxide	ZrO_2	[1314-23-4]	2029	6	338
		Intermediates			
titanium oxide	TiO_2	[13463-67-7]	1820	6	303
zinc oxide	ZnO	[1314-13-2]	602	2	301
lead oxide	PbO	[1317-36-8]	606	2	303
aluminum oxide	Al_2O_3	[1344-28-1]	1682–1326	6	280–221
thorium oxide	ThO_2	[1314-20-1]	2159	8	269
beryllium oxide	BeO	[1304-56-9]	1046	4	261
zirconium oxide	ZrO_2	[1314-23-4]	2029	8	253
cadmium oxide	CdO	[1306-19-0]	498	2	248
		Modifiers			
scandium oxide	Sc_2O_3	[12060-08-1]	1514	6	252
lanthanum oxide	La_2O_3	[1312-81-8]	1699	7	242
yttrium oxide	Y_2O_3	[1314-36-9]	1669	8	208
tin oxide	SnO_2	[18282-10-5]	1163	6	193
gallium oxide	Ga_2O_3	[12024-21-4]	1117	6	186
indium oxide	In_2O_3	[1312-43-2]	1083	6	180
thorium oxide	ThO_2	[1314-20-1]	2159	12	179
lead oxide	PbO_2	[1309-60-0]	970	6	161
magnesium oxide	MgO	[1309-48-4]	929	6	154
lithium oxide	Li_2O	[12057-24-8]	602	4	150
lead oxide	PbO	[1317-36-8]	606	4	151

zinc oxide	ZnO	[1314-13-2]	602	4	150
barium oxide	BaO	[1304-28-5]	1088	8	135
calcium oxide	CaO	[1305-78-8]	1075	8	134
strontium oxide	SrO	[1314-11-0]	1071	8	133
cadmium oxide	CdO	[1306-19-0]	498	4	124
sodium oxide	Na_2O	[1313-59-3]	502	6	83
cadmium oxide	CdO	[1306-19-0]	498	6	82
potassium oxide	K_2O	[12136-45-7]	481	9	53
rubidium oxide	Rb_2O	[18088-11-4]	481	10	48
mercury oxide	HgO	[21908-53-2]	284	6	47
cesium oxide	Cs_2O	[20281-00-9]	477	12	39

[a] Ref. 32.

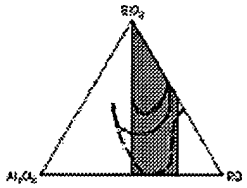
[b] To convert J to cal, divide by 4.184.

Glass formation of individual oxides can be predicted from the melting point, and individual bond energies can be normalized by dividing by the melting point of the oxide (33). This ratio is relevant because the melting point is related to the amount of thermal energy available to rupture bonds. If the bond energy is large and the melting point low, glass formation is favored. This explains the ease of glass formation of B_2O_3 and from low melting eutectics in which neither oxide forms a glass separately, eg, $CaO–Al_2O_3$.

Other correlations of glass formation and properties have been offered. For example (34): (*1*) cation valence should be three or greater, (*2*) glass formation should increase with decreasing cation size; and (*3*) the Pauling electronegativity should be between 1.5 and 2.1. Using these criteria, four types of oxides are described: (*1*) strong glass formers such as Si, B, Ge, As, and P; (*2*) intermediate formers that require rapid cooling, such as Sb, V, W, Mo, and Te; (*3*) oxides that form glasses in binary mixtures with nonglass formers, such as Al, Ga, Ti, Ta, Nb, and Bi; and (*4*) oxides that do not form glasses.

Glass composition work starts with the application of structural and bonding rules of glass formation. Numerous ternary systems and their glass-forming regions have been investigated (35). There are three types of ternaries: Type A, single former and two modifiers; Type B, two formers and one modifier; and Type C, three glass formers. Type A is shown in Figure 4. The

structural rules suggested in Reference 21 can also define likely regions for glass formation. Additions of several percent of other oxides for property adjustments are usually made to each system to give commercially useful glasses.



□**Figure**□**4.**□Glass-forming region in Type A system (35). The shaded area represents the predicted glass-forming region based on Zachariasen's rules (21). RO = BaO (—); SrO (— — —); CaO (— — —).□[Full View]

A parallel but more historically comprehensive discussion of glass structure and composition has been given (36). Prediction of structural parameters and consequent properties from theoretical principles has increased with the advent of supercomputers. Of particular interest to glass scientists are those studies which have focused on crystalline and vitreous silica (36, 37).

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